String Pots Enable CPR Mannequins to 'Talk Back'

The Project: Identify a method with which to determine whether or not chest compressions are being performed properly on a CPR mannequin.

The Solution: Attach cable extension transducers (i.e., string pots) to the chest area to measure the movement of the chest compression being applied.

By Jeffrey Rowe

The pale figure on the examination table went into cardiac arrest, displaying all the classic symptoms: loss of consciousness, irregular breathing, and sudden loss of blood pressure. The subject died quickly and suddenly, but the only thing the medical attendees did was looked at each other, shrugged their shoulders, and went home. Luckily, the "patient," named "Stan," was an HPS (Human Patient Simulator) medical training mannequin.

Compact sized string pot

For decades, medical personnel and members of the general public alike have been practicing the procedures involved with cardiopulmonary resuscitation (CPR) as well as other life saving medical techniques on CPR "dummies." Many used the old "Annie" style mannequins. Conversely, the medical emergency training today takes advantage of more advanced technology in the form of the HPS mannequin.

The HPS is a more advanced type of medical training mannequin that features sensors, pneumatics, computers, and diagnostic equipment, bundled together to give the training dummy "patient" a "living quality." It is designed to give more realistic feedback to the person being trained. Basically, the use of HPS technology

allows medics to obtain real world experience without the risk of real world dangers. The life-saving medical procedures can be practiced by medics repeatedly before they attempt them on an actual human patient in the field.

It has always been challenging to outfit the HPS units w
sensors to allow adequate measurement and feedback r
Chest compressions during CPR and air flow from mouth
examples of parameters that need measuring through th

The chest compression is a critical aspect of the HPS th
and repeatable measurement of the actual distance tha
compresses the chest during CPR procedures. The HPS r
searched for years to find a cost effective and durable li
before finally selecting string pots (i.e., cable extension
option.

HPS Design

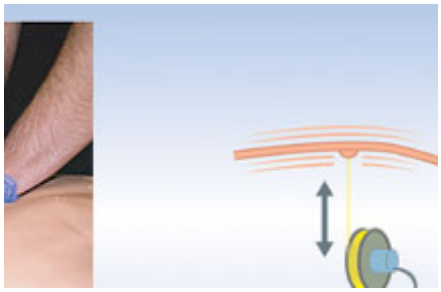
The modern HPS mannequin design allows faster and m
student, resulting in better “hands on training.” The HPS
communicating with the medical student in a much mor

Medical Education Technologies Inc. (METI) is a leader in
development of Human Patient Simulators. It has been i
manufacture of HPSs for well over a decade and has nic
“Stan.”

The most modern HPS designs employed by METI have
that allow a “pathological based” approach to the HPS fe
the HPS mannequin gives feedback to the medical stude
to just the medical instructor. (With older medical trainin
instructor received the feedback data from the mannequ
relay the information to the medical student.) With toda
is the focus, not the instructor.

How Real Is Stan?

Stan can exhibit over 72,000 combinations of physiologi
blinks, dilates, urinates, vomits, talks, and cries. Stan als
pulse points, an audible heartbeat, and exchanges air w
personnel can realistically insert an IV into Stan’s arm, a
and can even insert a needle into his skin. Stan’s eyes w
administering a sedative, and he can bleed realistic bloo



Above: Simulated chest compression

Right: Illustration of HPS Mannequin

Stan's skin is the most exotic material component on the HPS, made of a plastic/rubber type material commonly used for self-sealing tires in auto racing. This forgiving material allows the medic to puncture the "skin" over and over without permanent damage to the skin surface.

If the medical trainer applies a chest compression that is too weak, Stan will sense this and will give feedback showing that an improper amount of blood volume is being pumped. If a chest compression is applied boldly with too much force, then Stan will show structure damage or broken ribs.

Stan presents the users with 70 pre-programmed health conditions, such as cardiac arrest or diabetes, and the instructor can add other conditions on the fly, such as collapsed lungs, drug allergies, or asthma. When Stan goes into a simulated cardiac arrest, for example, the medic must perform proper CPR, use defibrillator pads, and administer the proper drugs in proper doses in order to stabilize his condition. The METI HPS gives real hands-on experience in administering proper CPR.

Measurement Challenges

When seeking out chest compression measurement methods, engineers faced a multitude of challenges.

Simplicity The HPS design engineers needed a sensing device that was simple to install and maintain; a device that used a complex, fragile technology was out of the question. The ideal solution would be some type of non-contact measurement method, but there were not too many options that met the engineers' test criteria. Engineers determined that they had a need for a relatively simple contact device.

Continuous Measurement The engineers needed a fully continuous linear measurement signal and not just a cycle-counter for chest compressions. Measuring the full length of each chest compression stroke gives the medical instructor more detailed data on the blood flow induced.

High Cycle Count Proper CPR techniques call for approximately 30 chest compressions per minute, depending on time for breathing. The very conservative HPS design needed to allow for approximately 300 to 500 cycles per training hour. At this rate, it is estimated that the sensor would have a life span of five to ten years&#151a relatively exceptionally long lifetime.

Good Signals The more complicated the signal, the more complex the sensor and data acquisition system needed. Most medical equipment manufacturers prefer a simple DC voltage signal for their products, so a basic potentiometer output was acceptable.

Compact Size The compact nature of the internal workings of the HPS mannequin makes the size of the linear measurement sensor critical. Most "rod and cylinder" type devices have a long profile that would not work for the HPS.

Medical design engineers tested several types of linear motion sensors during their design, but most proved to be too large or difficult to utilize for the chest movement application.

Solution

The engineers that designed the HPS realized that the linear sensor that measured the chest movement would need to be easily replaced and serviced. The units needed to be compact, simple, and durable in order to endure the rigors of daily use in the HPS.

Medical design engineers finally found a solution for the chest compression measurement by using cable extension transducers, or "string pots," as a method for accurate measurement. String pots allow a direct contact measurement that allows the sensor to be attached to the moving portions of HPS chest structure. As the chest is compressed for CPR, the string pot gives instantaneous measurement feedback with no delays and has no complicated linkages. This instantaneous measurement feedback allows the medical student to vary his chest compression technique quickly. The string pot linear measurement transducer used in the HPS is typically a unit with a 2.0 in. measurement length, and is about the size of a 2.0 in. cube. The unit weighs only a few ounces, comprised of aluminum and thermoplastic components to maintain the light weight. The base of the string pot is mounted inside the chest cavity, close to the chest wall. The 0.034 in. diameter measurement cable, about the thickness of kite string, is attached to the chest wall, so that the cable is actually retracting when the chest is compressed.

Cable extension transducers (string pots) are considered to be the optimum type of linear measurement device for the HPS due to a variety of reasons.

Excellent accuracy and linearity (0.10% – 0.25% is typical)
Outstanding repeatability (0.02% typical) and reliability
Ease of installation: simple attachment of both base and cable
Provides continuous measurement feedback
Fully serviceable in field: no reliance on the factory

Low cost and good availability of product
Absolute signals: can power off without loss of position
Output signals are available in basic standard voltage
3D motion is easily tracked

Additionally, several design details of the highly engineered string pot make it durable enough for the high cycle applications of the HPS mannequin.

Multi-stranded stainless steel measurement cable tested to exceed 10 million bending cycles.
Long-life rotary potentiometer provides a minimum of 2.5 million cycles.
The recoil spring is stainless steel and is designed to operate at low stress levels to achieve a minimum of 2.5 million cycles.

Without these basic design details, an older style, traditional string pot would not last nearly as long as a more modern, well-designed units. Refinements in design details have resulted in an order of magnitude increase in cycle life. The string pot has remained a solid solution for tracking movement on many types of OEM and test devices.

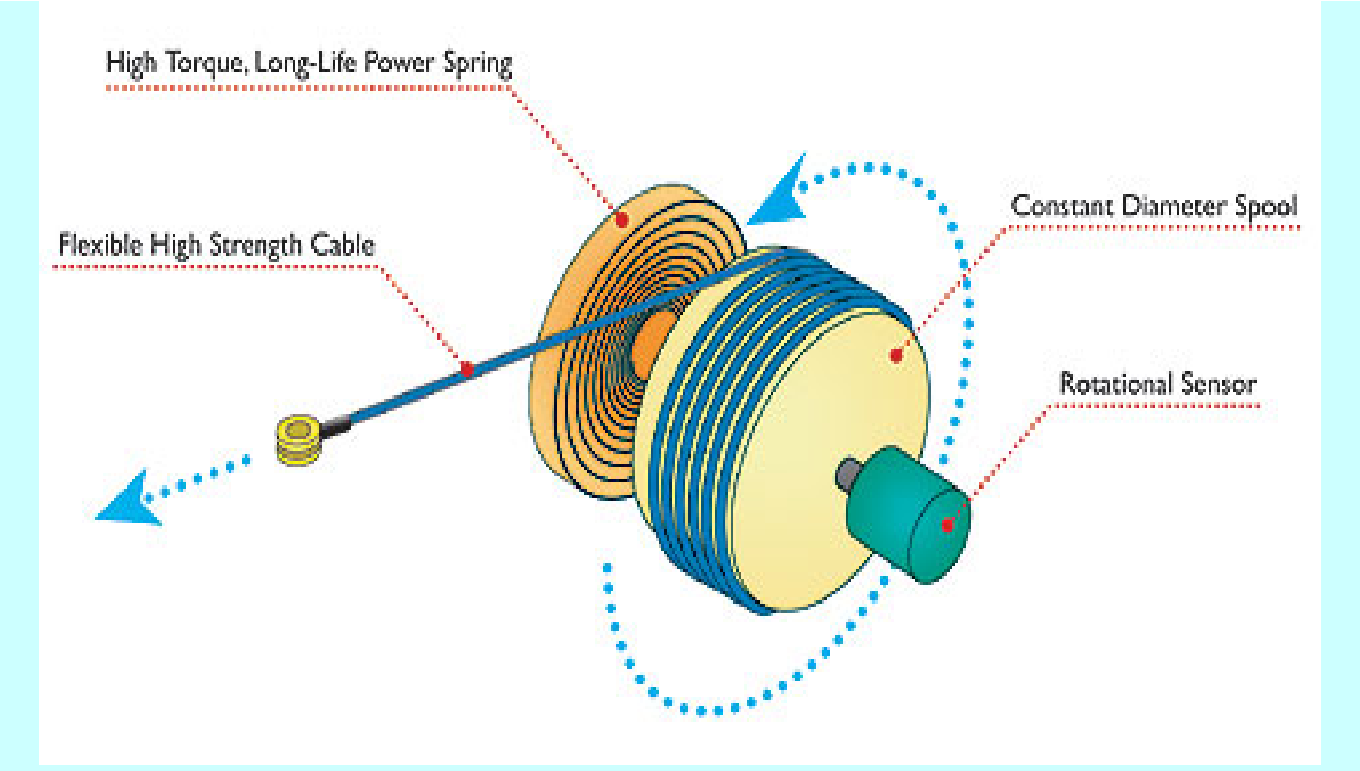
Cable extension string pots will continue to be used for medical applications due to their accuracy and reliability. Every year, string pots are getting smaller, lasting longer, and being designed for higher linearity.

The String Pot

A cable extension transducer (i.e., string pot) is a device used to measure linear position, using a flexible cable and spring-loaded spool.

The string pot's body is mounted to a fixed surface and the measurement cable is attached to the moving object. As the object moves, the transducer produces an electrical signal proportional to the cable's linear extension. This signal can then be sent to a display, data acquisition system or controller.

Inside the transducer's housing, a stainless steel cable is wound on a precisely machined, constant diameter cylindrical spool that turns as the measuring cable reels and unreels. To retract the cable, a spring is coupled to the spool; the spool is coupled to the shaft of the rotational sensor. As the transducer's cable extends, the spool and sensor shafts rotate, creating an electrical signal proportional to the extension.



ONLINE

For additional information on the technologies and products discussed in this article, see *Medical Design Technology* online at www.mdtmag.com [1] and the following websites:
www.celesco.com [2]
www.meti.com [3]

Jeffrey Rowe *is a Product/Sales Engineer with Celesco Transducer Products. He holds a mechanical engineering degree from Auburn University and an MBA from Cal State Long Beach. Rowe can be reached at 818-701-2750 or* jeff@celesco.com *[4].*

Source URL (retrieved on *12/10/2013 - 4:38am*):
http://www.mdtmag.com/articles/2007/01/string-pots-enable-cpr-mannequins-%E2%80%98talk-back%E2%80%99?qt-most_popular=0

Links:
[1] http://www.mdtmag.com
[2] http://www.celesco.com
[3] http://www.meti.com
[4] mailto:jeff@celesco.com